



## Film-centric science communication: Striking a balance between accuracy and visual storytelling

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### Abstract

What began as Public Understanding of Science (PUS) has over the years, transformed into Public Awareness of Science (PAS) and then to Public Engagement of Science (PES). However, what also remained at the center of the thought was the fact of 'bringing a new urgency to the question of the communication of science' to the public. With more widespread scientific literacy, the workers would be able to do their jobs better, managers and government would make better decisions and industry would become more competitive. In their personal lives, people would make better choices about their lifestyles, particularly if they understand risk better. Though the number of science films produced over the years has seen a rise, it has not been matched by the scholarly studies on them. Since celluloid films and television programs run larger risk of content dilution in order to appeal to a larger audience, it often results in a distortion of scientific facts while producing a media product. It is, therefore, important to apply caution during production and post-production of science films to ensure authenticity of content being treated in them. Research studies on this particular aspect of science film production is also seeking attention from scholars. Another important area where not enough research has been undertaken concerns the impact of science films as a media for science communication. This paper studies the literature that analyses the impact of science films and examines how effective films have proved for the public appreciation and understanding of science.

**Keywords:** Science films; Science documentaries; Science fiction films; Adolescent girls; Climate change

### 1. Introduction

Enquiry and examination into films as an art form and as an instrument of social change, with reference to its role as a medium of information, education and entertainment has already offered many insight into its role. The Public Engagement of Science (PES) model further implies that scientific progress is the result of a continuous process involving multiple stakeholders, which in turn calls for science communication to be seen as a means to optimize this mutual interaction as engagement in science. In this view, communication is a transaction process in which scientific as well as ethical and social considerations are taken into account. Public participation in science presupposes a certain level of public understanding and awareness; hence the experiences gained in activities focused on these aims are all relevant for the goals of public participation of science. Though films are an effective tool to achieve the intended participation, it is tough to actually get people involved. A simple and universal approach to achieving this is to hold the hands of 'entertainment, education and emotion' proposed in the 3E model. It believes 'entertainment' triggers attention, 'emotion' is found in identification with the subject, and 'education' is achieved by the raised curiosity.

Since films appeal to the imagination of people, its art and craft need sensitive handling, especially for scientific themes, because of its ability to impact behavior from the constructed message design which gets enhanced through the power of visuals and audio. Some of the rather recent films have been hugely successful in establishing a connect with the public. Films titled 'Cove, Gravity, Theory of Everything, Big Bang Theory and Interstellar' are some of the examples.

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Oscar winning documentary filmmaker and environment crusader Louis Psihoyos' new film 'Cove', which warns that humans are erasing other species off the earth. The film is on killing of whales in Japan. The film had a huge public impact. In 2010 when the film was released, the Japanese were killing 23,000 dolphins and porpoises a year. Now, they kill less than 6,000.

Academy Award winning films such as 'Gravity' 2013 and the 'Theory of Everything' 2014 and television ratings titan like 'CSI (Crime Scene Investigation)' 2000 and the 'Big Bang Theory' 2007, prove that the science-based entertainment products can be both critically acclaimed and financially successful. 'Gravity', 'Interstellar' and 'The Theory of Everything' combined with a huge interest in machines such as the Large Hadron Collider at CERN and the Mars Rover have created a buzz around physics which led to higher numbers of students applying to study the subject. The Institute of Physics said the number of UK students applying to study for a degree in physics had risen by 40% over four years, while numbers wishing to take physics at A-level had grown by 3% from 2012 to 2013. The production value of these films indicates a huge budgetary provision in their production [14]. Oxford University said it has seen applications for its physics undergraduate degree rise by a third over five years. Undergraduate applications for physics and astronomy at Manchester rose by 37% between 2008 and 2014, while its post-graduate applications increased by 40% over the same period.

Television programs have also had an impact which has pushed the frontiers like never before. The mass media impact of the Large Hadron Collider (LHC) and an introduction of an array of physics based programs targeted at the general public, and viewers with a specific interest was a proof again. Though the scores of other science films produced either on celluloid or television formats did not involve comparable production values, they evoked enough interest in the audience and were instrumental in initiating discussions on moral issues, apart from scientific.

The new generation of scientists and researchers and even institutions and organizations in the governments have begun active consideration to communicate research through films. This study reviews the literature that have examined, analyzed and addressed the importance and impact of science communication through films.

## 2. Methodology

This section contains the methodology of the study and the research papers selected for study. The papers studied the literature that analyzed the impact of science films as a medium for communicating science. The keywords used to search for the films were- science films, science documentaries, scientific films, scientific documentaries, science fiction films, scientific movies, science in cinema, science films for communication, science documentaries for communication, popular science films, impact of science films, science films in education, impact of scientific documentaries and impact of science fiction films. The papers were retrieved from the searches across various journals and publications including Google Scholar and social media platform- ResearchGate. Eight papers were retrieved from the searches that analyzed the impact of science films, science documentaries and science fiction films on various subject areas. A general lament was the fact that not enough research has been undertaken to examine the role of science films as a media for science communication. Eleven papers were selected for the present review. The research papers, research articles, and chapters from scientific books studied are listed in Table 1.

**Table 1** Research Papers/Research Articles/Chapters from scientific books studied

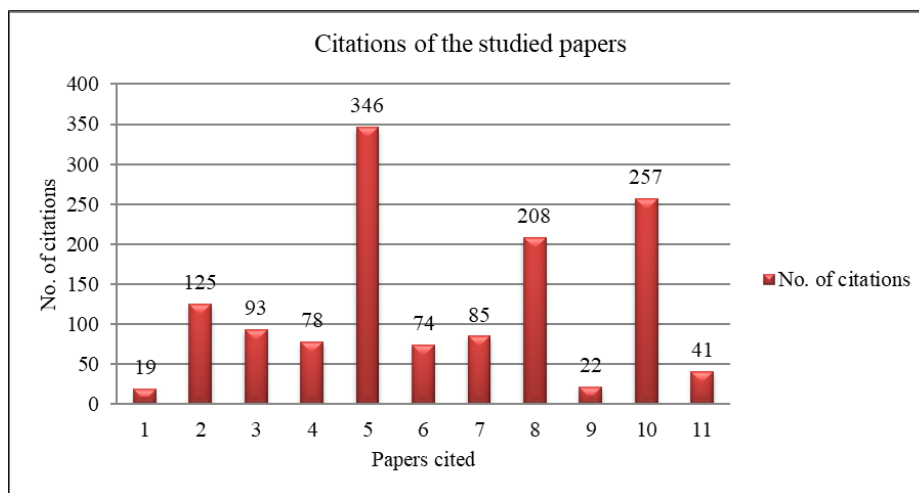
No.	Title	Author(s)	Year	Description
1	Audience Reactions to Climate Change and Science in Disaster Cli-fi Films: A Qualitative Analysis	Lauren N. Griffin	2017	This paper analyses the audience interpretation of disaster cli-fi films.
2	Cinematic Climate Change, a Promising Perspective on Climate Change Communication	Maria Sakellari	2014	This paper analyses how films on climate change affect people's everyday activity.
3	Communicating Climate Change through Documentary Film: Imagery, Emotion, and Efficacy	Ashley Bieniek-Tobasco, Sabrina McCormick, Rajiv N. Rimal, Cherise B.	2019	This paper examines the impact of climate change films on beliefs, expectations, responses, motivations,

		Harrington, Madelyn Shafer, Hina Shaikh		and intentions of the audience to address climate change.
4	Cinematic Science: The Public Communication of S & T in Popular Films	David A. Kirby	2008	This chapter discusses the role of cinema, particularly popular, fictional films, as a media for science communication and its impact on the public understanding of science.
5	Cultural Representations of Gender and Science: Portrayals of Female Scientists and Engineers in Popular Films	Jocelyn Steinke	2005	This paper studies the impact of popular science films on female scientists or engineer characters on adolescent girls.
6	Relative Effectiveness of Classroom and Documentary Film Presentations on Marine Mammals	Rosanne W. Fortner	1985	This paper compares the effectiveness of classroom learning and scientific documentary films on students.
7	Science and Technology in Film: Themes and Representations	David A. Kirby	2014	This chapter shows the emergence of science films as a media for science communication and its power to impact public understanding of science.
8	Science Consultants, Fictional Films, and Scientific Practice	David A. Kirby	2003	This paper studies the scientific practice of science films by examining its role in science communication.
9	Science Fiction Movies as a Tool for Revealing Students' Knowledge and Alternative Conceptions	Sevinc Ongel-Erdal, Duygu Sonmez, Rob Day	2004	This paper analyses the impact of science fiction films in developing critical thinking and understanding scientific concepts among students.
10	The Impact of Science Fiction Film on Student Understanding of Science	Michael Barnett, Heather Wagner, Anne Gatling, Janice Anderson, Meredith Houle, Alan Kafka	2006	This paper analyses the impact of popular earth-science fiction films on students.
11	The Usefulness of Climate Change Films	Kate Manzo	2017	This paper assesses the impact of climate change films and analyses the debates on the authenticity of scientific information in these films.

### 3. Results and Discussions

#### 3.1. Citations

Citations normally draw from the content and the publication date of the research papers. It is routine expectation for the papers published earlier to get a higher number of citations, as they have been read by more people than the ones published later. Another very important aspect is the content and its relevance with allied fields of investigations. As the subject area overlaps with other disciplines, it gains more citations. Citations can be classified as positive citations and negative citations. Both the types of citations are crucial for assessing the impact of research output [12]. The data presented here on the number of citations have been obtained from Google Scholars. In Google Scholar journals are grouped into scientific categories and are then ranked according to an h5-index, that implies- h-index for articles that are published in the last 5 years Braun et al., [13]. H5-index is the highest number of h, where h articles published in 5 years have at least h number of citations.



**Figure 1** of citations of the studied paper

The Fig. 1 represents number of citations of the studied paper. The article published by Steinke [5], 'Cultural Representations of Gender and Science Portrayals of Female Scientists and Engineers in Popular Films' got the highest number of citations, followed by article of Barnett et al. [10] titled 'The Impact of Science Fiction Film on Student Understanding of Science' received the second highest number of citations at 257. The article authored by Kirby [8] got 208 citations and was positioned third in the citation list, while the article authored by Sakellari [2] scored fourth with 125 citations. 346 citations received by the author Steinke [5], clearly established how the scientific world has focused on equality of gender in academics and supported the participation of women and girls in science, technology and engineering. This paper analyzed some of the films that featured female characters and concluded that the female characters have the potential to shape adolescent girls' perceptions about science and carving out a career in it. An alternate view on the role of gender in achieving positions of importance among scientists and engineers. The female characters shown in the films presented scientists and engineers in professional positions of high reckoning. However, their portrayals suggested a clear treatment that established them as more charming a character than the promise of attraction held out by the science. While this paper indicated annoyance at this traditional portrayal of female professionals, it laid emphasis on the prestigious positions enjoyed by the female scientists and engineers that may well inspire the adolescent girls to take science as a career. This paper focused on broadly three areas- science, science communication and sociology, which perhaps explain its high number of citations.

Kirby [8] analyzed the role of science consultants in cinema, particularly in popular science and science fiction films. Scientists and scientific organizations were mentioned to be one of the key elements in shaping the science film production, particularly by the Hollywood film industry. The author also brought out the fact of scientific knowledge not being restricted to scientific meetings, proceedings, research papers or publications, but also being open and receptive of science ideas presented in the form of articles, films, documentaries as well as stories. The study concluded by discussing the role of scientists or science consultants as an "act of persuasive communication" in impacting the understanding of science. Since this paper has been published earlier than the other studied papers and the subject of science communication dealt in the paper looks at its sociology as well, its gaining a higher number of citation is not too far to seek. Barnett et al. [10] analyzed how a popular science fiction film influenced students' understanding of earth sciences. This paper also mentioned that only a few studies have been undertaken to assess the impact of popular science films on students to promote their critical thinking and understanding of scientific concepts. The authors also presented how the visuals of science fiction films have influenced students' understanding of complex scientific concepts. When the students started to watch the simple scientific concepts already known to them (textual information/from schools), they tend to believe the rest of the complex scientific concepts being true. Also, the characters played a major role in science fiction films. When the characters shown came from a professional scientific background (scientists/engineers), the students readily believed the scientific facts told or explained by them as true. Again, in an interview, one of the students remembered a visual sequence from the film, rather than the classroom learning, as the basis of her explanation. An interesting finding of this study centered on the fact that when the films are produced with facts based on accurate scientific concepts and ideas, which are further treated for cinematic visualization in the films, the students tend to believe those stories to be ideally scientific. These findings suggest that science fiction films with authentic content treated equally true through skillful visual presentation has a significant impact on students' understanding of science content in the film as they journey through the unfolding of story in the film. Science communicators and science film makers must pay a great deal of attention to keep clear of uncalled for

distortion of scientific facts while conceptualizing visual sequences in the film. This holds true even for genres other than science fiction.

**Table 2** Position of studied papers according to citation received

Position of the papers studied	Paper No.	No. of citations received
1	5	346
2	10	257
3	8	208
4	2	125
5	3	93
6	7	85
7	4	78
8	6	74
9	11	41
10	9	22
11	1	19

Around the world, political influences and cultural beliefs have created a chasm between the scientific community and the general public while engaging in dialogue on matters of climate change. The discussions and debate by the scientific community on the complexity of climate issues often fail to influence the understanding of a layperson. Sakellari [2] mentioned that climate change films provide new information and affect climate change perceptions, however, they are ineffective in bringing about a long-term change in the behavior and attitude of viewers. This paper examined the potential role of films that entertained the audience scored better to advance climate change communication. The meta-analysis of the three films in this paper suggests that the cinematic events combined with new information in the films were not making a behavioral or attitudinal change in the lay audience. The author suggested that films on climate change that treated the storyline appealing to the emotion of the audience worked better at empowering people to address climate change impacts. The in-depth analysis undertaken in this paper have helped it gain an encouraging number of citations. Fortner [6] obtained the eighth place in acquiring citations as shown in Table 2. It presented a neutral but contradictory conclusion. This paper mentioned that the study conducted has resulted in an increased knowledge retention among students while they viewed a single environmental science documentary at home. However, it also mentioned science documentary as one of the media that is “merely a vehicle” to deliver knowledge. This paper also suggested, on the other hand, that science teacher should deliver the subject matter that is presented in the film, without using a television set. Teaching it in a regular class, in a teaching-learning manner could be a consideration. This paper also noted some of the disadvantages of teaching science through films but failed to mention the advantages. The conclusions stood quite opposed to the findings of the study. Manzo [11] was marked at the ninth position in getting citations. This paper analyzed the nature of some of the films that has focused on climate change issues. The author has evaluated the debates in the area of climate change communication, image manipulation and scientific films and concluded that as no scientific attempt can set out the whole “absolute truth or reality” likewise, no films can ever present the whole story. Thus, the debate is expected to be an ongoing process which “is as normal for films as it is for science”, the author mentioned. This is where the creativity applied in deciding an effective ‘treatment’ combined with the script writing skills make a visual sequence that much more watchable. The same degree of comprehension perhaps was tough to be achieved otherwise. Another significant point that the author established point concerned the post-production aspects of the film, especially its editing, which should not be understood the same as manipulation. He went on to conclude that climate change films were educative as well as effective. Despite their being effective, the author mentioned that the scientific content presented in documentaries must remain “truthful, open and honest”, no matter how the visuals have been sewn together. Published in 2017, the rich content and analysis got 41 citations.

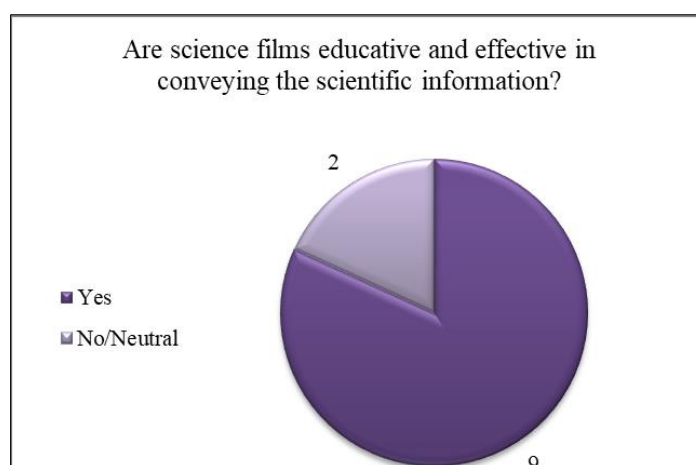
Kirby [7] discussed cinematic science as a powerful tool in shaping cultural and social aspects of science. It also analyzed the increased popularity of science in the entertainment media, whether it is cinema, news media, or web series. Though the author is appreciative of the potential of filmic images of science being used in production of science for creating

excitement about the subject among the audience, he also seems concerned about striking the right balance between science content and the use of cinematic tools for communicating science while keeping the audience entertained at the same time. This study gained 85 citations. The article authored by Kirby [4] and Ongel-Erdal et al. [9] received 78 and 22 citations respectively. Kirby [4] mentioned the influence of popular science films in shaping the “cultural meanings” of science. It discussed the need of science consultants to maintain the authenticity of the scientific information in the films. Most of the science fiction films released before the year 2000 were themed on horror, where science has been treated as an element of horror. This often interferes with the understanding of science. The science films produced after the year 2000 though are a departure from such a trend. It presented authentic scientific information in the films, where scientists as consultants helped to collaborate in creation of powerful fictional stories to strengthen the plot of films. This paper also looked at science films as a “complicated research field” and suggested treating this area as an important and noteworthy field of academic rigor. Ongel-Erdal et al. [9] concluded from its analysis that science fiction films help students in understanding of scientific concepts as well as in development of critical thinking which contribute to their ability for making a distinction between actual scientific facts and the fictionalized scientific visuals in the films. The students were also seen to create alternative scientific ideas to problems that were shown in the science fiction films. The data of their study suggested a homogenous result, irrespective of gender or countries, even though the questions asked were translated into different national languages of the countries concerned.

Bieniek-Tobasco et al. [3] investigated the efficacy of film or documentaries as climate communication modalities. It revolved around the documentary years to understand the audience response and the gained motivation towards climate actions. The study suggested that documentaries should not miss compelling stories and cinematic imagery to bring in behavioral changes in the viewers. It was published in 2019 and has 93 citations. Climate fiction is a niche area with the potential to impact the subject of climate communication. Griffin [1] evaluated the emotional response of the audience towards the three climate fiction films themed on disasters. The evaluation showed that the audience found it difficult to connect with the films. They also harbored doubts about the films’ ability to affect attitudes and beliefs about climate change. A sizeable number of scholars and researchers have already wondered “How many citations does an academic article need to establish its influence?” It has been quite a job to provide a satisfactory answer to the question. The number of citations per paper depends on several bibliometric indicators that include a host of factors. The chief among them are the Eigen factor, g-index, h-index and impact factor. Again, the citations per paper are normally higher in multidisciplinary sciences as against an exclusive field. These indicators are unhelpful when comparing an engineer with a scientist or a poet with a cinematographer [15]. Thus, comparing productivity on the basis of only citations of a paper is replete with doubts.

Out of all the eleven scholarly articles that have been studied, David Allen Kirby emerged as the author of three papers with highest cumulative citations at 371. The British professor of science communication mentioned the role of scientists as consultants for science films and the importance of maintaining scientific authenticity in scientific films and documentaries. He also seems to have repeatedly laid emphasis on the limited research that has been undertaken in the field of reaching out with science through films and the need to actively augment studies on the multi-disciplinary and complex nature of production of science films.

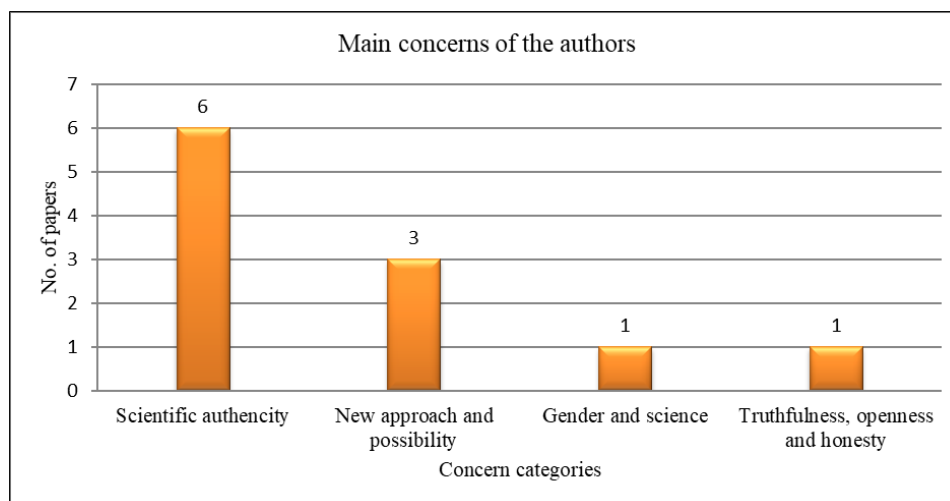
### 3.2. Impact of the film



**Figure 2** Studies on impact of science films

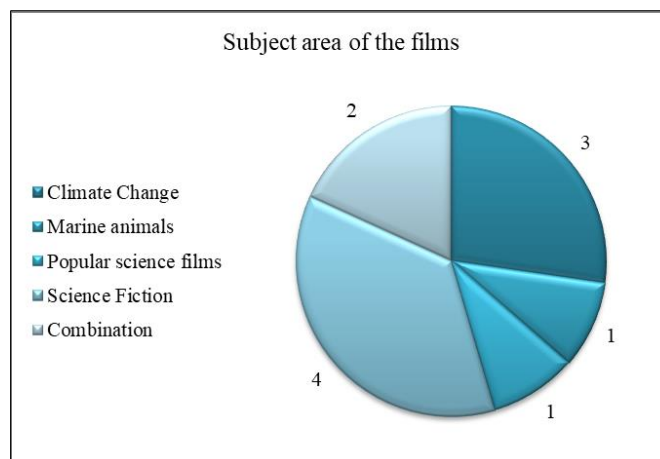
Fig. 2 shows studies on impact of science films. Except Griffin [1] and Fortner [6], all the reviewed articles have concluded that as a medium for science communication, science films have a positive impact on the audience. Griffin [1] mentioned audience (postgraduate students) pointing out the exaggeration of visuals and effects used in cli-fiction films while compromising with the accuracy and actuality of the climate disasters shown in the films. Fortner [6] concluded that if the same content of documentary on marine mammals was taught in classroom it would have a better effect on the knowledge retention by students, as they would have a chance to interact with classmates as well as the educators.

### 3.3. Interest areas and considerations of the literature reviews



**Figure 3** Main concerns of the authors

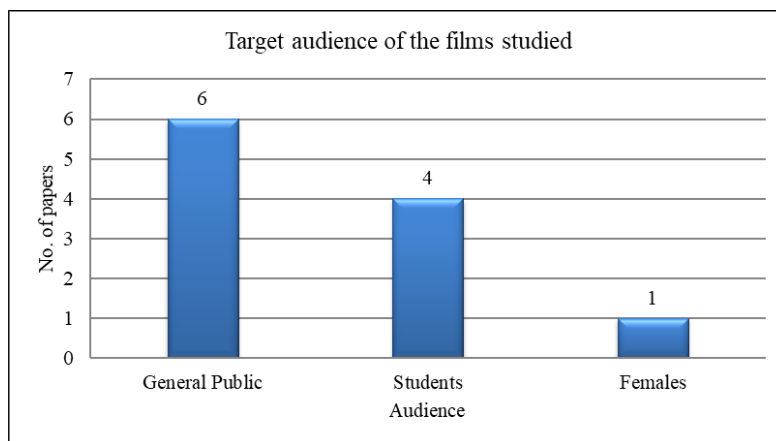
Fig. 3 highlights the main concerns of the authors regarding science films. It shows that Griffin [1], Kirby [4], Kirby [7], Kirby [8], Ongel-Erdal et al. [9] and Barnett et al. [10] considered scientific authenticity to be prioritized more in the films to effectively communicate accurate scientific concepts. Meanwhile, Sakellari [2], Bieniek-Tobasco et al. [3] and Fortner [6] considered edutainment to be a new approach and an effective manner of treatment for science communication. Sakellari [2], however, suggested that climate change films should modify their presentation styles by including visualization of the individual responsibility while framing climate change issues in the films. This may possibly be more effective in altering the behavior of the viewers and be successful in creating a long-term positive effect. Bieniek-Tobasco et al. [3] showed that the climate change films created concern and desire among the viewers to take action against climate change. Steinke [5] considered the importance of portrayal of female characters in science films who enjoyed higher scientific positions. Though most of the films based on female scientists or engineers prioritized elements of feministic characters over scientific information, this paper suggested that such characters may motivate adolescent girls to take up science as a career. This paper also considered the societal position of girls in the scientific world and hence concluded the positive effect of female oriented science films. Manzo [11] considered the truthfulness, honesty and openness to be prioritized in science films, particularly films on climate change. The author also emphasized the importance of presenting a scientific concept as a story without distorting the facts either through oversimplification or by giving undue precedence to visual styles that might make the films more entertaining. These concerns are of great importance while communicating through science films. Bieniek-Tobasco et al. [3] compared the learning of students through classroom teaching and teaching science through science documentaries. Though it mentioned that science documentary viewing increased the knowledge retention of students, the paper concluded that science film is merely a media to educate when watched in isolation of a home, while classroom teaching is more effective, when the students get to interact among themselves more while being together. The paper was published in 1985, the time when the entertainment media was evolving continuously. It is quite possible that the historical fact colored the author's belief to hold a non-favorable view about television. These disadvantages affected the access to the world of entertainment. Mass viewing of films in schools was also adversely impacted due to lack of equipment required for projection.



**Figure 4** Genres of the films analyzed by the papers

Sakellari [2], Bieniek-Tobasco et al. [3] and Manzo [11] examined the usefulness and impact of films based on climate change, Fortner [6] compared the effectiveness of viewing documentaries on marine mammals to that of its classroom teaching and Kirby [4] focused on the analysis of the effect of science communication through popular science films. Kirby [7], Kirby [8], Ongel-Erdal et al. [9] and Barnett et al. [10] analyzed the impact of science fiction film as a mode of science communication. Griffin [1] analyzed the impact of disaster climate-fiction films on the audience by studying their responses which is based on presentation of films in the area of climate change and science fiction. Steinke [5] examined the impact of female character oriented scientific films on adolescent girls. The articles authored by Griffin [1] and Steinke [5] have been included in the category- combination representing different genres as shown in Fig. 4.

### 3.4. Target audience



**Figure 5** Target audience of reviewed papers

Fig. 5 shows the target audience of reviewed papers. Some films are made to target a particular group, others such as most of the climate change films focused on a broad target audience. The impact and response towards a film also depended on the audience. For example, science fiction film targeted at kids was not expected to be as equally appreciated and responded to by teenagers or adults. Griffin [1], Fortner [6], Ongel-Erdal et al. [9] and Barnett et al. [10] focused on the impact of films on students, whereas Sakellari [2], Bieniek-Tobasco et al. [3], Kirby [4], Kirby [7], Kirby [8] and Manzo [11] analyzed the influence of science films on audience with no particular focus on any definite group. They had a large heterogeneous group constituting of general public. Steinke [5], however, examined the effects of science films on adolescent girls that had female characters.

## 4. Conclusion

It has been found that most of the papers concluded that science films have been successful in creating appreciable impact on the target audience. It also contributed to increased appreciation and understanding of science by students.



However, the body of literature suggests maintenance of scientific authenticity and its prioritization in the films rather than the filmic visuals. Few authors have also mentioned that the non-judicious use of sound and visual effects that create a non-true situation which is in variance with real-life and the facts in the scientific world. One of the papers mentioned the importance of truth, honesty and openness of the scientific information that would need to be prioritized in science films. Though the climate change films and documentaries have shown to have made quite an impact on the audience, the papers also pointed out at the same time, that the impact was not maintained long-term. One of the papers that analyzed the impact of climate change films clearly suggested individual responsibility towards concerns for striking a balance in matters of nature. It was concluded that this could be a pointer which might help in altering the long-term behavior of audience in a positive manner. Films on science fiction have got positive response from the audience, especially students. Students liked the films which were based on accurate scientific information and concept and later moved to more fictionalized visuals. Films of this genre were expected to help in understanding of scientific concepts and promote critical thinking among the students. One of the literatures mentioned the importance of science films featuring female characters. It was shown to have influenced the day-to-day life of adolescent girls and may also be instrumental for making a choice in favor of studying a subject and carving out a career in science.

Science films have proved to be a powerful and effective mode for communicating science. An increasing number of electronic media products as well as productions on celluloid are being attempted that are directly or obliquely themed on science. The void of scholarly studies on science films has never been felt as critically as in the present times, especially in view of the discipline experiencing technological innovations by the day and its importance being acknowledged better than ever, both by public as well as specialists. Since the practice and impact of science films depends to a large extent on the degree of understanding of the complex interplay of disciplines ranging from not just science and its sociology, but also the strengths that are drawn from video and film engineering which calls for a deep understanding of the mechanics of optics combined with integration of appropriate film technology while dealing with visual, audio, graphic and communication design to skillfully create a science story either on celluloid or television. It is, therefore, best seen and treated as an ever more collaborative effort among film producers, directors, scientists, production technicians, science researchers as well as sociologists who collectively ensure a successful marriage of scientific rigor and accuracy with the art, craft and aesthetics of filmmaking.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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